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SAMUEL FELTMAN
AMMUNITION LABORATORIES

PICATINNY ARSENAL
DOVER, N. J.

FRAGMENTATION TEST

RECORD NO. 287

DATE August 1954

SUBJECT:

Shell, HE, 60 mm, Folding Fin, Typed BD-106-1,
Metal Parts Assembly

54AA 60589

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GFlartey/hb/4160
Picatinny Arsenal, Dover, N.J.
6 August 1954

TEST RECORD NO: 287

REFERENCE: Project No. Tal-1402

DESCRIPTION OF AMMO: Shell, HE, 60 mm, Folding Fin Type BD-106-1, manufactured by the Budd Company from Steel, Carbon, Bar Stock, U.S. 1020, Spec QQ-S-633.

DRAWING NUMBERS: Complete Round: WS-5154X, Rev 1/21/54
Shell Loading: WD-5196X, WD-5197X, 2/5/54
Shell Metal Parts: WS-5152-X, Rev 1/12/54
(Assembly & Details)

QUANTITY IN LOT: 3 in each lot

QUANTITY FRAGMENTED: 6

METHOD FUNCTIONING: Modified M52 Fuze, Drawing 73-1-161, initiated with Corps of Engineering blasting cap.

PURPOSE OF TEST: The object of this test was: (a) to compare the fragmentation properties of TNT-loaded type BD-106-1 folding fin Shell metal parts with those of the Comp B Type BD-106-1 folding fin Shell metal parts and (b) to compare the fragmentation properties of the Type BD-106-1 Shell (both TNT and Comp B-loaded) with those of similarly loaded Shell, HE, 60 mm T24.

FRAGMENTATION PROCEDURE: 6 Shell were fragmented at ambient temperature. (3 shell TNT-loaded, 3 shell Comp B-loaded). The shell were assembled equipped with electric ignition and placed in a pine box with $\frac{1}{2}$ " wall thickness. The overall dimensions of the box were 8" x 8" x 16". The box was placed on end over 6' of sawdust in a 14' - 9" deep fragmentation tub, 15' - 5" in diameter at the top and tapering to 13" diameter at the bottom. The box was covered with 5' of sawdust.

FRAGMENTATION RECOVERY
& CLASSIFICATION:

Fragments were recovered from tub by sifting the sawdust on a mechanically-operated screen of No. 8 Mesh (.093" opening, .032 wire diameter), using a magnetic separator. The fragments were classified by weight and grouping according to the following weight zones:

Group 0 - 0 to $\frac{1}{2}$ grain

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7

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6 August 1954

Group 1 - $\frac{1}{2}$ to 2 grains
Group 2 - 2 to 5 grains
Group 3 - 5 to 10 grains
Group 4 - 10 to 25 grains
Group 5 - 25 to 50 grains
Group 6 - 50 to 75 grains
Group 7 - 75 to 150 grains
Group 8 - 150 to 750 grains
Group 9 - 750 to 2500 grains
Group 10 - Over 2500 grains

The 60 mm mortar shell metal parts assemblies, Type BD-106-1 which were fragmented during the course of this test were of two-piece silver soldered base plug construction as shown on Drawing No WB-5152- -X, Rev 1/12/54. The complete round assembly fragmented consisted of both the shell body and folding fin and boom assembly. The folding fin and boom assembly (integral) was attached to the threaded end of the base plug on the shell body. The fin and boom assemblies were manufactured from aluminum alloy, 24 ST - 4, Spec QQ-A-354a. The steel and aluminum fragments were recovered, segregated into two groups, counted, and recorded separately. The steel fragments were recovered by means of a magnetic separator and the aluminum fragments were recovered manually.

Discussion & Conclusions:

Based on the limited data available, the following observations were made:

Considering the opinion that effective lethality is obtained only with fragments occurring over 10 grains in size, Comp B-loaded shell produced a greater total number of effective fragments than the TNT-loaded shell.

The average total number of Comp B-loaded steel shell fragments occurring above 10 grains is 454 and the average total number of TNT-loaded steel shell fragments occurring above 10 grains is 399.

The average total number of Comp B-loaded shell aluminum fragments occurring above 10 grains is 27.

The average total number of TNT-loaded shell aluminum fragments occurring above 10 grains is 34.

A graphical representation of the data given in the preceding three paragraphs is shown in Figure 1.

A curve of percent average cumulative weight of steel shell fragments versus group number for the TNT and Comp B-loaded shell, respectively, is shown in Figure 2.

7

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The "Percent average cumulative weight" is based on the average weight of fragments (per group number) of each group of 3 projectiles on the inclosed data sheets.

By definition, the average cumulative weight of fragments equals the average weight of fragments in a group, plus the average weight of fragments in all preceding groups. The percent average cumulative weight of fragments is defined as the ratio of the average cumulative weight to the average weight of the empty shell.

Average total weight of Comp B-loaded steel shell
fragments occurring between 10 and 50 grains
divided by weight of empty shell

X 100 = 44%

Average total weight of TNT-loaded steel shell
fragments occurring between 10 and 50 grains
divided by weight of empty shell

X 100 = 37.5%

The statement, made above, that effective lethality is obtained only with fragments occurring over 10 grains in size, and also the statement that fragments in the weight range of 10 to 50 grains constitutes the optimum casualty producing size of fragment, is based entirely on the criterion established by Watertown Arsenal as given in 1st Indorsement, 3-2-54, Watertown Arsenal to Picatinny Arsenal, ORDBE-L 471.2/1824, ORDBB 471.14/10-122, subject: "Fragmentation Characteristics of Shell and Test Cylinders of Case and Forged Steels (Project TAL-1546D)".

However, if the assumptions relative to the nature of terrain, effect of fragment velocities, and wound ballistics contained in various Ballistic Research Laboratories Reports, by: T. Sterne, et al, are followed, the conclusions probably would be changed and the shell and explosive combinations giving fine degrees of fragmentation might be moved up into higher categories of preference. This involved decisions to be made only after consideration by higher echelons, such as Service Board, ORO, and WSEG, and probably would require acquiring information on fragmentation, velocity and distribution patterns which is presently not available.

Regardless of which of above criteria are used, however, it appears that the Comp B-loaded Type BD-106-1 shell yielded fragmentation properties slightly superior to those of the TNT-loaded Type BD-106-1 shell. Both TNT and Comp B-loaded Type BD-106-1 shell metal parts yielded fragmentation characteristics superior to those of similarly loaded Shell, HE, 60 mm, T24 Metal Parts as reflected in Picatinny Arsenal Fragmentation Report No. 279

G. R. FLARTY

George R. Flarty

3
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T. C. Armitage
J. H. D. ARMITAGE
Col, Ord Corps
Director, SFAL

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PICATINNY ARSENAL FRAGMENTATION TEST

Mortar 60mm Boat Tail Folding Fin

Projectile: Steel, Carbon, Bar Stock; FS 1020

Explosive Filler: TNT Design BD-106-1

Type Fuze: P.D. M52 Mod. Initiated with an Eng. Corps Blasting Cap.

Size of Box: 8" x 8" x 16" 1/2" Pine

Recovery Medium: Sawdust #8 Mesh Screen and Magnetic Separator.

Test Record No: 2340

Sheet 1 of 4

		PROJECTILE NO.			
		1		2	
Requested by Mr. G. Flartey		Steel	Alum	Steel	Alum
Wt. Empty Lbs.		2.68	.78	2.68	.78
Wt. Loaded Lbs.		4.30		4.29	
Number and Weight of Recovered Fragments	No. 0 Group Not 0 to 1/2 Grs. Counted	Through a 10 Mesh Screen (U. S. Std Sieve Series)			
	Wt. Lbs.	.06	.01	.05	.01
	No. 1 Group 1/2 to 2 Grs.	No. 751	54	712	63
	Wt. Lbs.	.12	.01	.12	.01
	No. 2 Group 2 to 5 Grs.	No. 440	3	343	74
	Wt. Lbs.	.20	.03	.17	.04
	No. 3 Group 5 to 10 Grs.	No. 243	25	198	22
	Wt. Lbs.	.25	.02	.21	.02
	No. 4 Group 10 to 25 Grs.	No. 251	20	219	17
	Wt. Lbs.	.59	.04	.50	.04
	No. 5 Group 25 to 50 Grs.	No. 107	7	91	10
	Wt. Lbs.	.54	.04	.48	.05
	No. 6 Group 50 to 75 Grs.	No. 30	6	28	7
	Wt. Lbs.	.26	.05	.25	.06
	No. 7 Group 75 to 150 Grs.	No. 28	2	37	1
	Wt. Lbs.	.43	.02	.62	.01
	No. 8 Group 150 to 750 Grs.	No. 8		9	1
	Wt. Lbs.	.22		.24	.09
	No. 9 Group 750 to 2500 Grs.	No.			
	Wt. Lbs.				
	No. 10 Group 2500 and Larger	No.	1		1
	Wt. Lbs.		.54		.43
Total No.		1858	173	1637	185
Total Wt. Lbs.		2.67	.76	2.64	.76
% of Fragments Recovered		99.6	97.4	98.5	97.4
Photo No.		M44781		M44782	
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PICATINNY ARSENAL FRAGMENTATION TEST

Projectile: same

Test Record No: 2340

Explosive Filler: TNT Design BD-106-1

Sheet 2 of 4

Type Fuze:

Date: 6 May 1954

Size of Box:

Recovery Medium:

			3 PROJECTILE NO.			
			Steel	Alum		
Wt. Empty Lbs.			2.68	.78		
Wt. Loaded Lbs.			4.30			
Number and Weight of Recovered Fragments	No. 0 Group Not	Through a 10 Mesh Screen (U. S. Std Sieve Series)				
	0 to 1/4 Grs. Counted	Wt. Lbs.	.05	.01		
	No. 1 Group	No.	725	22		
	1/4 to 2 Grs.	Wt. Lbs.	.11	.01		
	No. 2 Group	No.	387	58		
	2 to 5 Grs.	Wt. Lbs.	.18	.03		
	No. 3 Group	No.	225	26		
	5 to 10 Grs.	Wt. Lbs.	.23	.03		
	No. 4 Group	No.	225	14		
	10 to 25 Grs.	Wt. Lbs.	.49	.03		
	No. 5 Group	No.	90	9		
	25 to 50 Grs.	Wt. Lbs.	.43	.05		
	No. 6 Group	No.	25	6		
	50 to 75 Grs.	Wt. Lbs.	.21	.05		
	No. 7 Group	No.	32	1		
	75 to 150 Grs.	Wt. Lbs.	.51	.01		
	No. 8 Group	No.	17			
	150 to 750 Grs.	Wt. Lbs.	.46			
	No. 9 Group	No.				
	750 to 2500 Grs.	Wt. Lbs.				
	No. 10 Group	No.		1		
	2500 and Larger	Wt. Lbs.		.54		
Total No.			1726	137		
Total Wt. Lbs.			2.67	.76		
% of Fragments Recovered			99.6	97.4		
Photo No.			783			
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PICATINNY ARSENAL FRAGMENTATION TEST

Projectile: same
 Explosive Filler: Comp B Design BD-106-1
 Type Fuze:
 Size of Box:
 Recovery Medium:

Test Record No: 2340

Sheet 3 of 4

Date: 6 May 1954

			PROJECTILE NO. 2			
			Steel	Alum		Steel
						Alum
Wt. Empty Lbs.			2.68	.78		2.68
Wt. Loaded Lbs.			4.36			4.35
Number and Weight of Recovered Fragments	No. 0 Group Not	Through a 10 Mesh Screen (U. S. Std Sieve Series)				
	0 to 1/4 Grs. Counted	Wt. Lbs.	.12	.01		.10
	No. 1 Group	No.	1084	38		987
	1/4 to 2 Grs.	Wt. Lbs.	.17	.02		.15
	No. 2 Group	No.	523	68		616
	2 to 5 Grs.	Wt. Lbs.	.25	.03		.28
	No. 3 Group	No.	336	22		332
	5 to 10 Grs.	Wt. Lbs.	.34	.02		.34
	No. 4 Group	No.	280	14		311
	10 to 25 Grs.	Wt. Lbs.	.60	.03		.69
	No. 5 Group	No.	109	4		92
	25 to 50 Grs.	Wt. Lbs.	.54	.02		.45
	No. 6 Group	No.	22	9		12
	50 to 75 Grs.	Wt. Lbs.	.19	.07		.10
	No. 7 Group	No.	26			27
	75 to 150 Grs.	Wt. Lbs.	.38			.41
	No. 8 Group	No.	2			4
	150 to 750 Grs.	Wt. Lbs.	.05			.11
	No. 9 Group	No.				
	750 to 2500 Grs.	Wt. Lbs.				
	No. 10 Group	No.		1		1
	2500 and Larger	Wt. Lbs.		.54		.54
Total No.			2382	206		2381
Total Wt. Lbs.			2.64	.74		2.63
% of Fragments Recovered			98.5	94.8		98.1
Photo No.			M44784			M44785
CONFIDENTIAL			7			

CONFIDENTIAL**PICATINNY ARSENAL FRAGMENTATION TEST**

Projectile: same
 Explosive Filler: Comp B Design BD-106-1
 Type Fuze:
 Size of Box:
 Recovery Medium:

Test Record No: 2340

Sheet 4 of 4

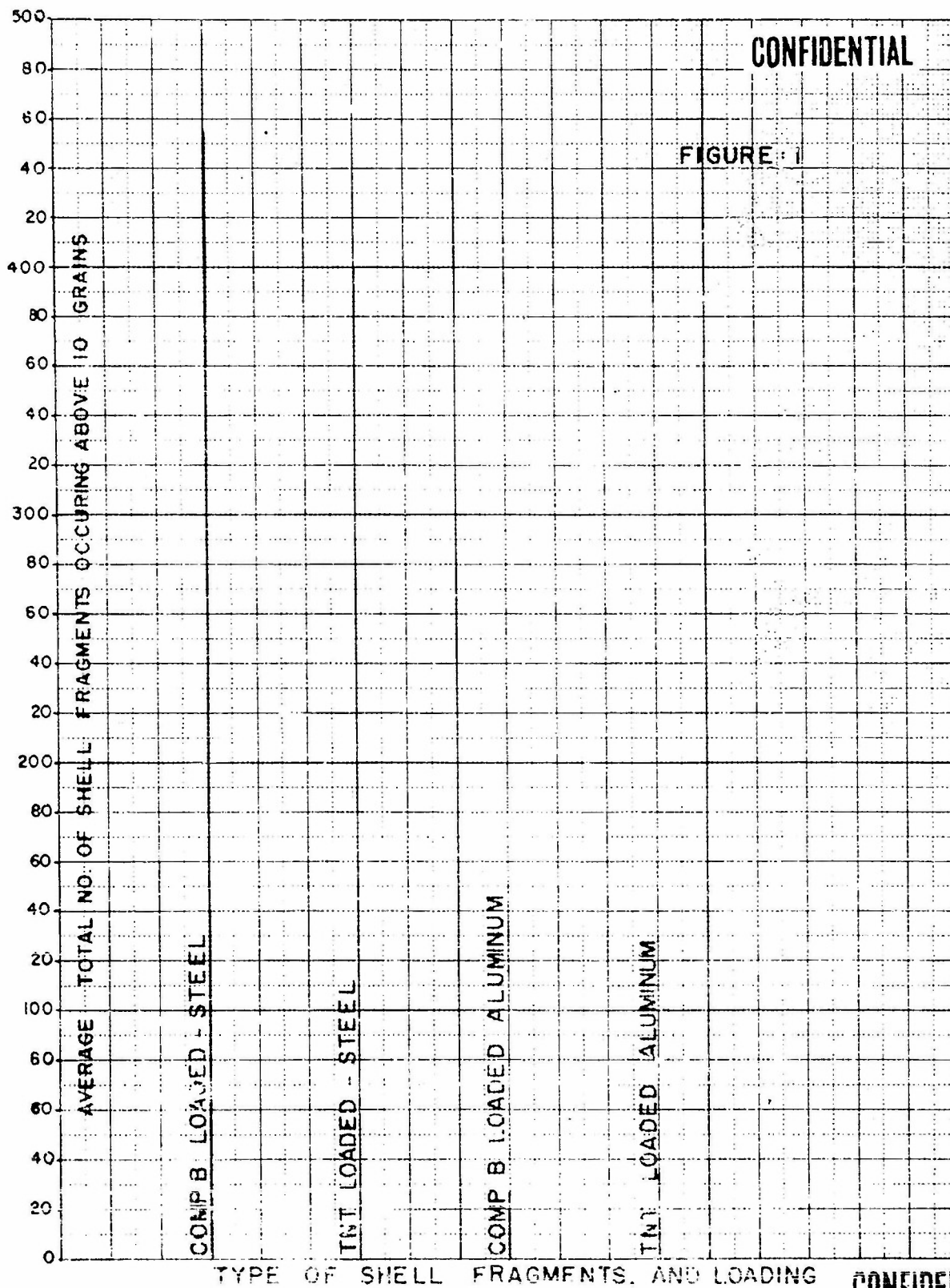
Date: 6 May 1954

Approved by L. F. Page
 Chief, Testing Section

Reviewed by L. D. Berrow
 Chief, Proof Testing Unit

Prepared by J. Smalinski

			PROJECTILE NO.			
			3			
			Steel	Alum		
Wt. Empty Lbs.			2.68	.78		
Wt. Loaded Lbs.			4.37			
Number and Weight of Recovered Fragments	No. 0 Group Not 0 to 1/4 Grs. Counted	Through a 10 Mesh Screen (U. S. Std Sieve Series)				
		Wt. Lbs.	.08	.01		
	No. 1 Group 1/4 to 2 Grs.	No.	1117	136		
		Wt. Lbs.	.16	.02		
	No. 2 Group 2 to 5 Grs.	No.	488	60		
		Wt. Lbs.	.22	.03		
	No. 3 Group 5 to 10 Grs.	No.	313	37		
		Wt. Lbs.	.32	.04		
	No. 4 Group 10 to 25 Grs.	No.	319	12		
		Wt. Lbs.	.69	.03		
	No. 5 Group 25 to 50 Grs.	No.	100	4		
		Wt. Lbs.	.43	.03		
	No. 6 Group 50 to 75 Grs.	No.	27	9		
		Wt. Lbs.	.23	.07		
	No. 7 Group 75 to 150 Grs.	No.	26			
		Wt. Lbs.	.42			
	No. 8 Group 150 to 750 Grs.	No.	2			
		Wt. Lbs.	.05			
	No. 9 Group 750 to 2500 Grs.	No.				
		Wt. Lbs.				
	No. 10 Group 2500 and Larger	No.		1		
		Wt. Lbs.		.53		
Total No.			2392	259		
Total Wt. Lbs.			2.65	.76		
% of Fragments Recovered			98.8	97.4		
Photo No.			M44786			
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FIGURE 1

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FIG. 2

PERCENT AVERAGE CUMULATIVE WEIGHT

TYPE OF FRAGMENTS - STEEL

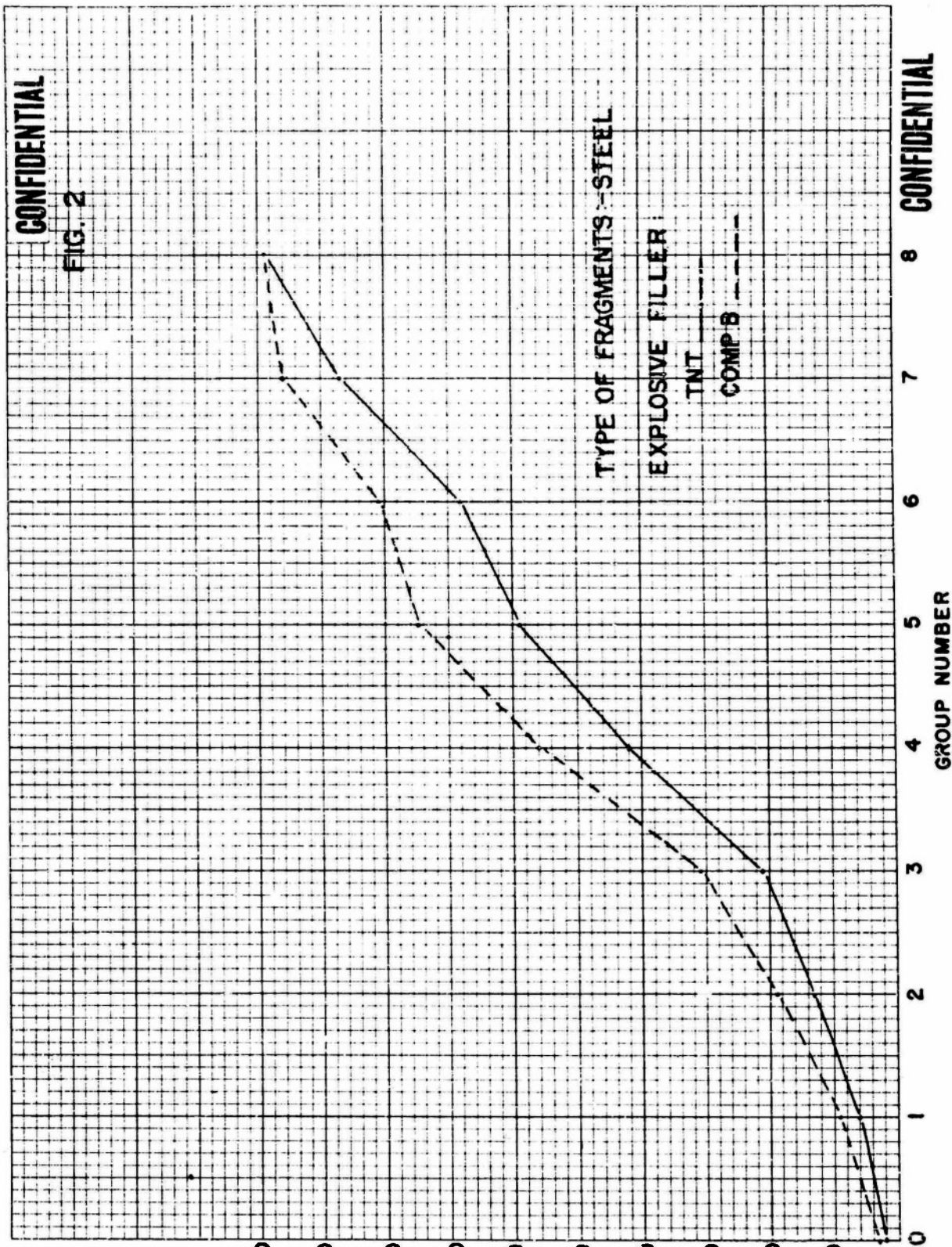
EXPLOSIVE FILLER:

TNT

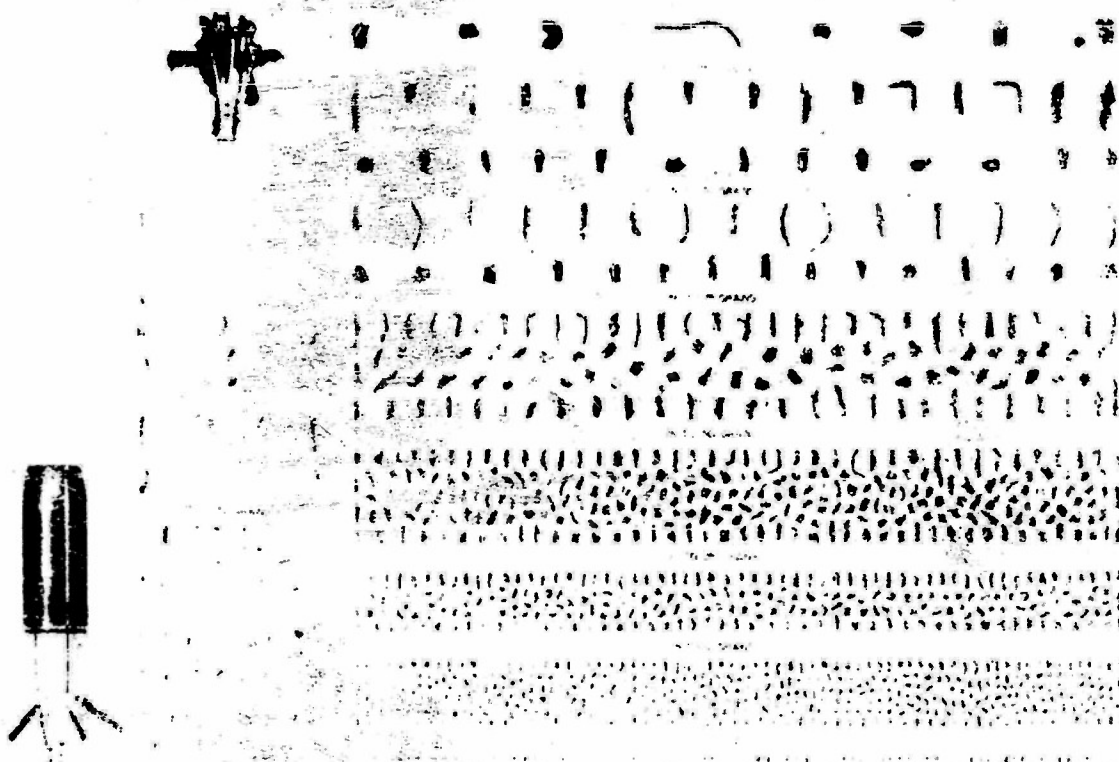
COMP B

GROUP NUMBER

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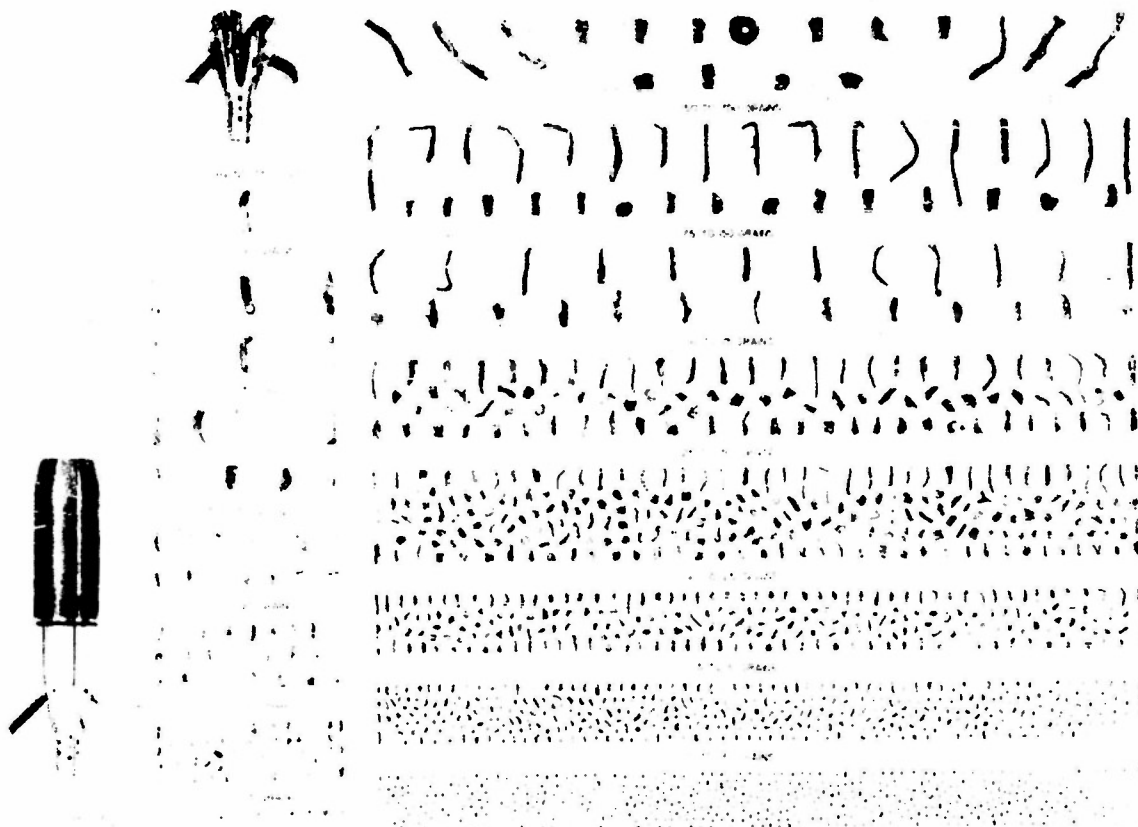


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This image displays a dense, repeating pattern of small, dark, vertical strokes, resembling a barcode or a heavily textured surface. The pattern is composed of numerous thin, dark lines of varying heights and widths, arranged in a somewhat regular but slightly irregular grid-like fashion. The background is white, creating a high-contrast, black-and-white effect. The overall appearance is that of a close-up of a textured material or a digital representation of a barcode.

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1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300 301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400 401 402 403 404 405 406 407 408 409 410 411 412 413 414 415 416 417 418 419 420 421 422 423 424 425 426 427 428 429 430 431 432 433 434 435 436 437 438 439 440 441 442 443 444 445 446 447 448 449 450 451 452 453 454 455 456 457 458 459 460 461 462 463 464 465 466 467 468 469 470 471 472 473 474 475 476 477 478 479 480 481 482 483 484 485 486 487 488 489 490 491 492 493 494 495 496 497 498 499 500 501 502 503 504 505 506 507 508 509 510 511 512 513 514 515 516 517 518 519 520 521 522 523 524 525 526 527 528 529 530 531 532 533 534 535 536 537 538 539 540 541 542 543 544 545 546 547 548 549 550 551 552 553 554 555 556 557 558 559 560 561 562 563 564 565 566 567 568 569 570 571 572 573 574 575 576 577 578 579 580 581 582 583 584 585 586 587 588 589 590 591 592 593 594 595 596 597 598 599 600 601 602 603 604 605 606 607 608 609 610 611 612 613 614 615 616 617 618 619 620 621 622 623 624 625 626 627 628 629 630 631 632 633 634 635 636 637 638 639 640 641 642 643 644 645 646 647 648 649 650 651 652 653 654 655 656 657 658 659 660 661 662 663 664 665 666 667 668 669 670 671 672 673 674 675 676 677 678 679 680 681 682 683 684 685 686 687 688 689 690 691 692 693 694 695 696 697 698 699 700 701 702 703 704 705 706 707 708 709 710 711 712 713 714 715 716 717 718 719 720 721 722 723 724 725 726 727 728 729 730 731 732 733 734 735 736 737 738 739 740 741 742 743 744 745 746 747 748 749 750 751 752 753 754 755 756 757 758 759 760 761 762 763 764 765 766 767 768 769 770 771 772 773 774 775 776 777 778 779 780 781 782 783 784 785 786 787 788 789 790 791 792 793 794 795 796 797 798 799 800 801 802 803 804 805 806 807 808 809 810 811 812 813 814 815 816 817 818 819 820 821 822 823 824 825 826 827 828 829 830 831 832 833 834 835 836 837 838 839 840 841 842 843 844 845 846 847 848 849 850 851 852 853 854 855 856 857 858 859 860 861 862 863 864 865 866 867 868 869 870 871 872 873 874 875 876 877 878 879 880 881 882 883 884 885 886 887 888 889 890 891 892 893 894 895 896 897 898 899 900 901 902 903 904 905 906 907 908 909 910 911 912 913 914 915 916 917 918 919 920 921 922 923 924 925 926 927 928 929 930 931 932 933 934 935 936 937 938 939 940 941 942 943 944 945 946 947 948 949 950 951 952 953 954 955 956 957 958 959 960 961 962 963 964 965 966 967 968 969 970 971 972 973 974 975 976 977 978 979 980 981 982 983 984 985 986 987 988 989 990 991 992 993 994 995 996 997 998 999 1000 1001 1002 1003 1004 1005 1006 1007 1008 1009 1010 1011 1012 1013 1014 1015 1016 1017 1018 1019 1020 1021 1022 1023 1024 1025 1026 1027 1028 1029 1030 1031 1032 1033 1034 1035 1036 1037 1038 1039 1040 1

12 11 10 9 8 7 6 5 4 3 2 1

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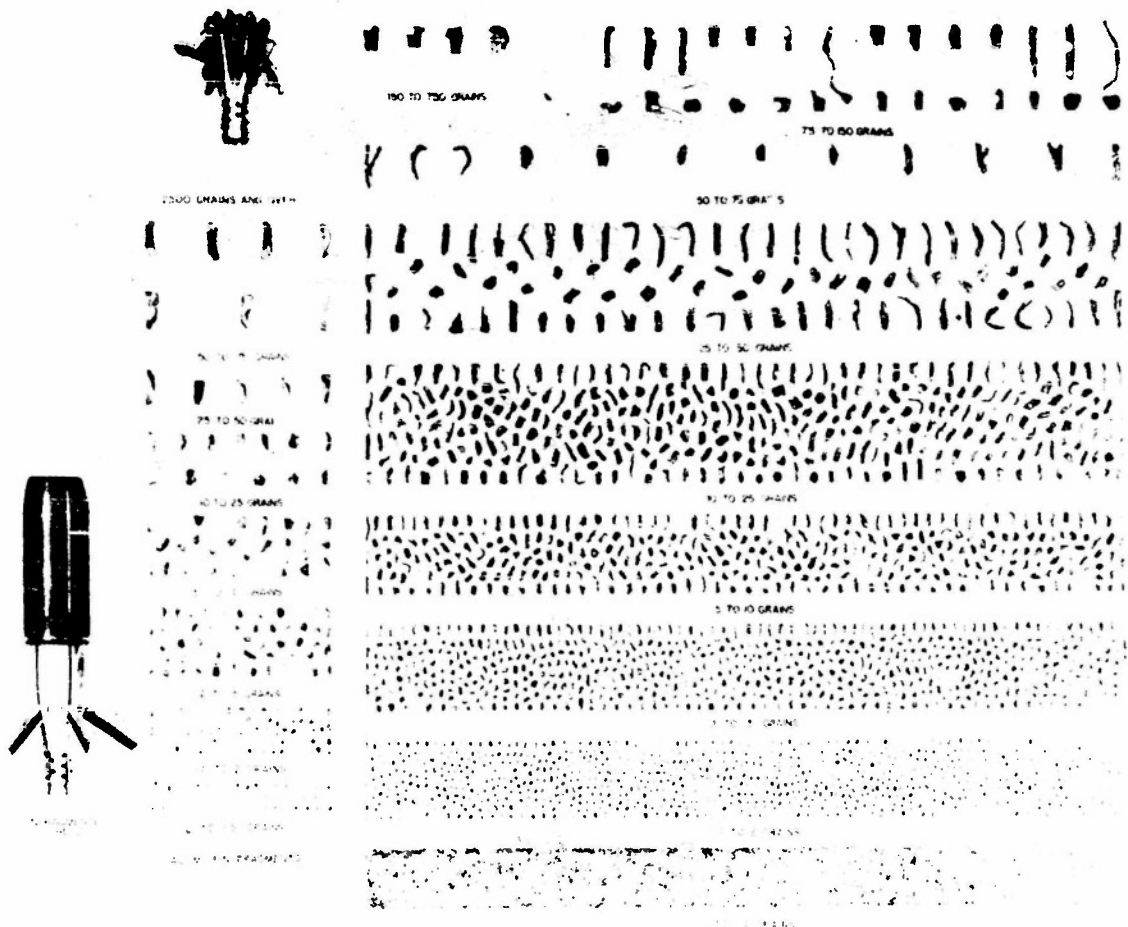
11. The following table shows the number of people who attended the concert in each of the five years from 1990 to 1994. The number of people who attended the concert in 1990 was 1000. The number of people who attended the concert in 1991 was 1200. The number of people who attended the concert in 1992 was 1500. The number of people who attended the concert in 1993 was 1800. The number of people who attended the concert in 1994 was 2000.

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion. The number of people aged 65 and over is expected to increase from 250 million to 450 million. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion.

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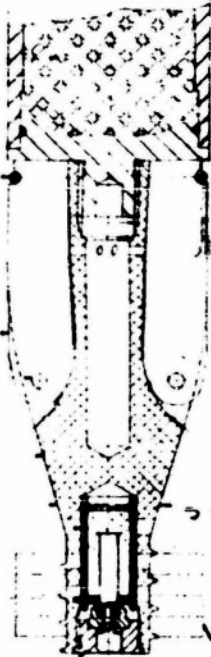
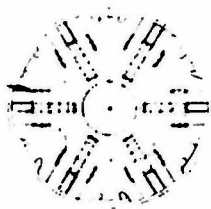
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WD-5454X

RED END OF CARTRIDGE TO BE
PLACED NEAR TO HEATER.

7 RESS FIVE 1/2 P. 1000
1/2 1/2 1/2 1/2 1/2
1/2 1/2 1/2 1/2 1/2



PROJECT OF DAY
PROPELLANT SUPPLIED
BY ORDNANCE

CHIC TO BE CONTINUED
WITH DM. B. WITHIN 90
TOTAL IN EXERCISE 2. 100%

1975 MAR

ALL INFORMATION CONTAINED
HEREIN IS UNCLASSIFIED

WOMEN
1. 100% NEW! 100% NEW! 100% NEW!
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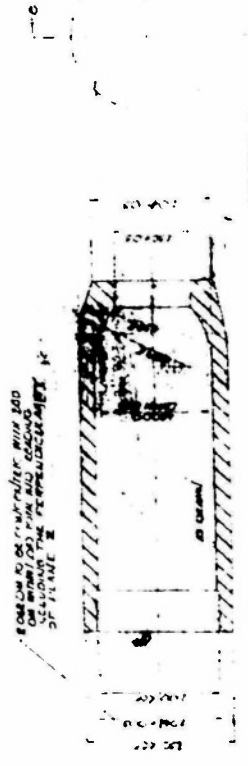
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